A set of water ice properties for Mars

- https://gemelli.spacescience.org/~wolff/files/aerosols/ice/

- Current version: droxtal_050_tmat1_reff_v010_ver121.fits.gz

Terrestrial Water Ice cloud database

- Yang et al.,J. Atm Science (2013): 330–347
- Bi, Lei, and Ping Yang, JQSRT 189 (2017): 228–237.
- https://zenodo.org/record/5348402#.Y5IJ4S-B240

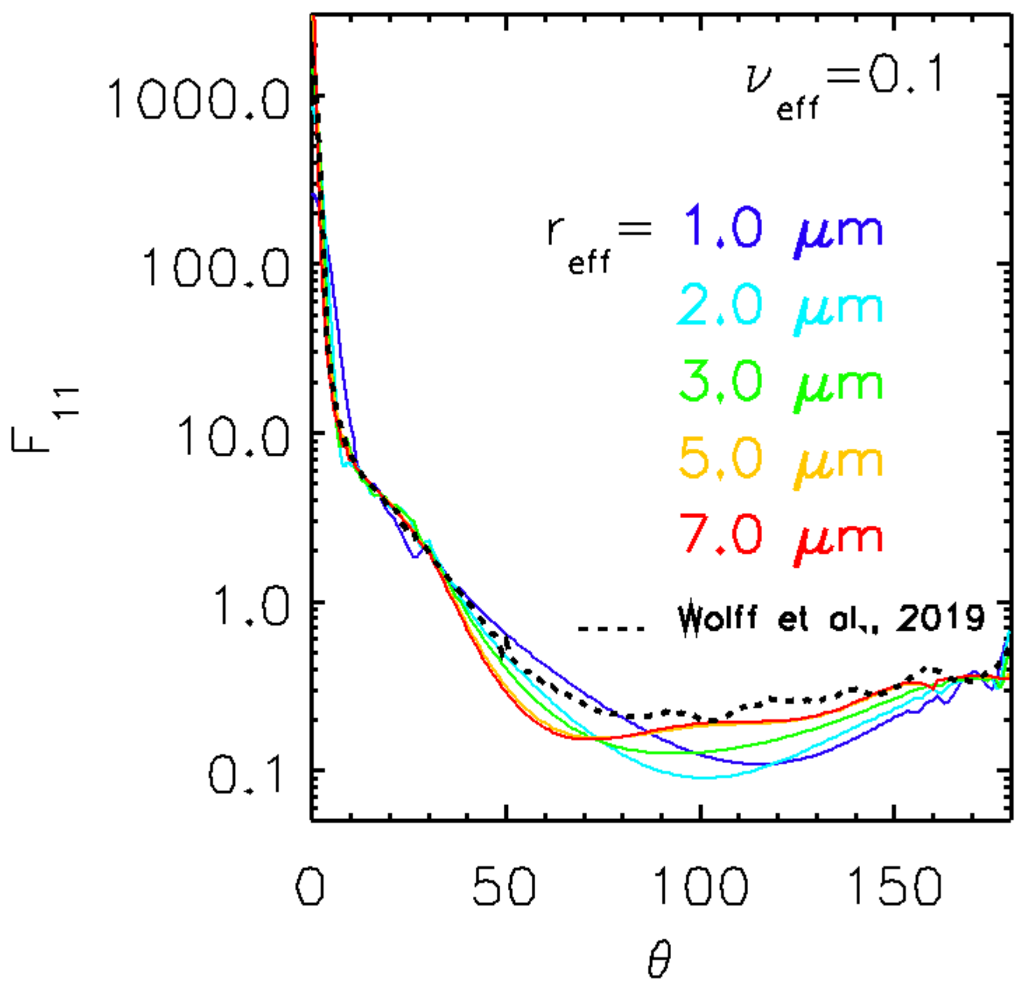
Applying to Mars

- Chose the “severely rough” droxtals shape, but the database only contains particles larger than ~0.9 µm (equivalent sphere radius).
- Extended to smaller sizes using T-Matrix oblate cylinders, D/L=1
- Wavelength range included: 0.2 – 99 µm
- Table built with ν_{eff}=0.1, and r_{eff}= 0.01, 0.05, 0.10, 0.20, 0.25, … (0.25)… 12.25, 12.5 µm (surface area equivalent spheres)
- Limitations:
  - Refractive indices from Warren and Brandt (2008), so T ~ 266 K
  - The particle size mesh in the TAMU database is not adequate on the small size portion of the mesh – size integrals do NOT remove the interference structure, so empirical methods are used.

How do these compare to the previous version of truth and beauty?

Apparently, I got the normalization a bit wrong at larger scattering angles…in any case, several cases from this datafile/database compared to the empirical phase function derived from MARCI.

However, things are reasonable, and I think that the droxtals shape remains a reasonable approximation of the polycrystalline habit suggested for smaller ice particles (i.e., smaller than typical terrestrial cases).



File structure - FITS

- FITS was chosen to allow easy storage of unlike objects with significant software support in the public domain.
- The primary header contains general information about the database construction
- The primary data unit is not used.
- The various quantities are stored in the associated Header Data Units (HDUs)

HDUs

NW = number of wavelengths, NR = number of r_{eff}, NMOM = number of Legendre terms, NT = number of angles

- Extension 1 -- FORW   Cext, Csca, g -- (3, NW, NR)
- Extension 2 -- PMOM   Legendre coefficients of PHSFN (NW, NR, NMOM)
- Extension 3 -- PHSFN phase function (F_{11})   (NW, NR, NT)
- Extension 4 – EXPANSION expansion of F_{11} using PMOM (NW, NR, NT)
- Extension 5 -- PARTICLE_SIZES r_{eff}(µm) (NR)
- Extension 6 – WAVELENGTHS (µm)
- Extension 7 -- SCATTERING_ANGLE (degrees) (NT)
- Extension 8 -- OFORW original FORW, before empirical correction
- Extension 9 -- OPHSFN original PHSFN, before smoothing

Useful KEYWORDS in the Primary Header

```
DATE    = '2023-10-31'      / Creation UTC (CCCC-MM-DD) date of FITS header

VERSION = '    1.21'        / Version of (this) library generation software.

FIX_F11 = '1       '        / Phase function size grid artifacts removed

EQUSPH  = 'AREA    '        / radius of equivalent sphere using area

VEFF    =             0.100000 / v_{eff}, 2nd moment of size distribution

MODEL   = 'droxtal_050_tmat1'  /base model
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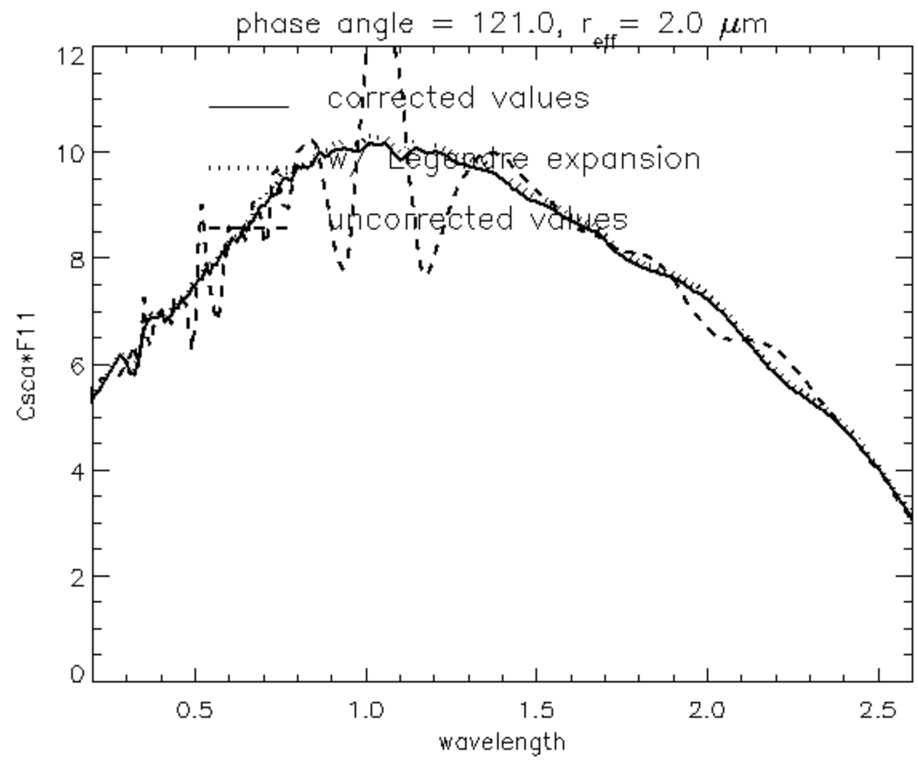
Example of interference structure due to coarse mesh – r_{eff} = 2.0 µm

The structure is present in the wavelength dependence of both the forward scattering properties and the angular variation of the phase function.

This can be dramatically apparently in the scattering perspective, where the observational geometry is essentially F_{11}*Csca.

This is clearly visible in the dashed line to the right (the size integrated TAMU database values). We take two approaches: 1) polynomial fitting in wavelength space for the forward scattering in the optical regime and 2) smooth in a range of scattering angles.

The improvements can be seen after empirical correction using the corrected phase function (solid) and the Legendre expansion of it (dotted). Discrepancies in the two corrected cases shows the limitation of the Legendre expansion with the number of terms used (here 192, see reff=8.0 µm case on next page)



Two more examples with larger particles